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Joint Service Aircrew Mask (JSAM) – Tactical Aircraft (TA) Modified A/P22P-14A (V)3: Noise Attenuation and Speech Intelligibility Performance

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Interim Report

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14. ABSTRACT
Noise attenuation and speech intelligibility measurements were conducted in accordance with American National Standards Institute (ANSI) S12.6-1997 Methods for Measuring the Real-Ear Attenuation of Hearing Protectors and ANSI S3.2-2009 Method for Measuring the Intelligibility of Speech over Communication Systems on the modified A/P22P-14A (V)3 with the HGU-55/P flight helmet. Attenuation and speech intelligibility performance measurements were also conducted with Attenuating Custom Communication Earpiece System (ACCES) worn in combination with the helmet and hood. The objective of these measurements was to determine if the JSAM-TA performance specification requirements were being met. When worn in combination with the HGU-55/P and the modified A/P22P-14A (V)3, ACCES increased noise attenuation across all frequencies, ranging from 125 Hz to 8000Hz, when compared to the helmet/hood configuration alone. Both configurations failed to meet the speech intelligibility requirement (≥ 85%) for low noise environments when using a torso-mounted communications unit, with scores for both configurations at 57%. Speech intelligibility requirements were met or exceeded for the required high noise environments, when hardwired into an aircraft communication system, with scores ranging from 85% to 92%.

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EXECUTIVE SUMMARY

The noise environment in the cockpit of military fighter aircraft can be hazardous to hearing and degrade speech communication performance. Flight helmets have been required to protect the pilot from potentially hazardous noise exposure and also provided effective speech communication. Chemical/biological (CB) protective equipment has also been required to protect aircrew in an actual or perceived CB warfare environment. Wearing CB protective equipment under a flight helmet could potentially degrade the noise attenuation performance of the helmet and earcups and therefore degrade speech communication capability as assessed by measuring speech intelligibility. Noise attenuation measurements were collected in accordance with the American National Standards Institute (ANSI) S12.6-1997 Methods for Measuring the Real-Ear Attenuation of Hearing Protectors[1] and speech intelligibility measurements were collected in accordance with ANSI S3.2 Method for Measuring the Intelligibility of Speech over Communication Systems[2] on the modified A/P22P-14A (V)3 CB hood and the HGU-55/P flight helmet. Additionally, noise attenuation and speech intelligibility measurements were conducted with Attenuating Custom Communication Earpiece System (ACCES) worn in combination with the hood and helmet. Measurements were conducted at the Air Force Research Laboratory's (AFRL) bioacoustics facilities at Wright-Patterson Air Force Base (WPAFB) in May 2015. The noise attenuation and speech intelligibility results were assessed relative to the Joint Service Aircrew Mask (JSAM) – Tactical Aircraft (TA) Performance Specification[3] requirements for ground and in-flight operations. The noise attenuation performance of the modified A/P22P-14A (V)3, when worn in combination with the HGU-55/P and ACCES, met the JSAM-TA requirements and exceeded the attenuation performance of the modified A/P22P-14A (V)3 with HGU-55/P alone. The speech intelligibility performance of the modified A/P22P-14A (V)3 and the HGU-55/P with and without ACCES was unacceptable in the low noise environments using a torso-mounted communications unit and did not meet the JSAM-TA requirement for speech intelligibility. The modified A/P22P-14A (V)3 and HGU-55/P with and without ACCES met or exceeded the JSAM-TA speech intelligibility requirement when connected to an aircraft intercommunication system.

1.0 INTRODUCTION

The noise environment in the cockpit of military fighter aircraft can be hazardous to hearing and degrade speech communication performance. Flight helmets have been required to protect the pilot from potentially hazardous noise exposure and also provided effective speech communication. Chemical/biological (CB) protective equipment has also been required to protect aircrew in an actual or perceived CB warfare environment. Wearing CB protective equipment under a flight helmet could potentially degrade the noise attenuation performance of the helmet and earcups and therefore degrade speech communication capability as assessed by measuring speech intelligibility.

The Gentex HGU-55/P flight helmet has been donned by F-22 pilots to combat noise in the cockpit and to provide satisfactory voice communications. The helmet system

included an Oregon Aero zetaliner, standard earcups, and standard helmet assembly bayonets and chin strap. The standard HGU-55/P configuration for the F-22 also included the MBU-20/P oxygen mask.

The modified A/P22P-14A (V)3 hood was manufactured by Cam Lock and was the Chemical, Biological, Radiological, and Nuclear (CBRN) respirator assembly evaluated as an interim solution for F-22 pilots. The modified A/P22P-14A (V)3 was planned to be worn in combination with the HGU-55/P to provide CB protection to the respiratory system in an actual or perceived CB warfare environment (Figure 1). The modified A/P22P-14A (V)3 was designed for individual pilot head/eye, respiratory and percutaneous protection against chemical and biological (CB) warfare agents, and protection against CB agent permeation. When integrated with aircraft-mounted and pilot-mounted equipment, the system would provide combined (simultaneous as required) hypoxia, CB, and anti-G protection. The modified A/P22P-14A (V)3 configuration included the hood assembly with a rubber hood cowl that incorporated a tear-away feature, a rubber neck seal, a closeable hood outlet valve, a demist hose, and an Advanced Dynamic Oxygen Mask (ADOM). The ADOM oronasal mask included an articulation visor, inhalation/exhalation valves, inlet hoses, microphone, drink capability, and helmet universal bayonets. The hood assembly was worn under the HGU-55/P flight helmet using bayonet receivers to assist in maintaining an oronasal seal. The hood featured a pass through with a Nexus connector for ACCES. The torso assembly was composed of an oxygen hose X-Manifold, lower breathing hoses, couplers, pusher fan, pusher fan battery, C2A1 canister filter for ambient air, C2A1 canister filter for aircraft oxygen, and a communications unit. Although the modified A/P22P-14A (V)3 respirator was available in sizes ranging from XXS to XL, only the small and large respirator with the standard cowl were available for measurements.

Figure 1. JSAM-TA (HGU-55/P in combination with the Modified A/P22P-14A(V)3)

Communication earplugs, like Westone's ACCES (Figure 2), have been integrated for use with flight helmets in order to improve the noise attenuation and speech intelligibility performance of the combined systems. ACCES were passive hearing protection/communication devices composed of mono audio cabling (part number 79801) and custom silicone earpieces (earpiece style AXAMK) that provided communication capabilities. These ACCES earplugs were vented for use in a high performance military jet aircraft.

Figure 2. ACCES (custom silicone earpieces with communication cabling)

The objective of this study was to measure the noise attenuation and speech intelligibility performance of the modified A/P22P-14A (V)3 in combination with the HGU-55/P with and without ACCES to determine if the JSAM-TA met the performance specification requirement as shown below.

JSAM-TA Performance Specification[3], dated 3 February 2015

3.4.8.3 Hearing Protection / Noise Attenuation

The JSAM when integrated with existing head-mounted personal/life support equipment in Appendix E shall result in no more than a 3 dB degradation of the measured one-third octave band hearing protection compared to the non-CB configuration.

3.4.4.1 Low Level Noise

Objective: To further assist with intelligible voice communication on the ground between CB protected personnel, and between CB protected aircrew and both CB protected and unprotected ground personnel at a distance of three meters apart, ground speech communication should be audible in an environment with 65-70 dB background pink noise without breaking the seal of the system or loss of CB protection.

4.3.4.2 Low dB - 65-70 dB background pink noise

If tested to objective requirements, speech intelligibility testing shall be accomplished per ANSI S3.2 and Appendix J using a minimum of ten talkers (five male and five female) and a minimum of ten listeners. The test shall be conducted wearing JSAM TA with each helmet listed in Appendix E at a distance of three meters apart with 65-70 dB background pink noise. The test shall result in a Modified Rhyme Test (MRT) Score of > 85%.

3.4.4.2 High Level Noise

Objective: To further assist with intelligible voice communication on the ground between CB protected personnel, ground speech communication should be audible in an environment with 71-115 dB background pink noise without loss of CB protection.

4.3.4.3 High dB - 71-115 dB background pink noise

If tested to objective requirements, speech intelligibility testing shall be accomplished per ANSI S3.2 and Appendix J for each background pink noise level using a minimum of ten talkers (five male and five female) and a minimum of ten listeners. The test shall be conducted wearing JSAM TA with each aircrew helmet listed in Appendix E and using an appropriate communication amplification device in the presence of 75-115 dB background pink noise.

The speech intelligibility test shall result in a MRT Score as listed in Table 4-3 below depending on the background noise level:

Table 4-3:MRT Score

Pink Noise Overall Sound Pressure Level (dB SPL)	*Modified Rhyme Test Score (% Correct)*
75	*95*
95	*90*
105	*85*
115	*80*

2.0 METHODS AND RESULTS

2.1 Continuous Noise Attenuation

Twenty paid volunteer subjects (10 male, 10 female) participated in the continuous noise attenuation performance measurements. The subjects ranged in age from 19 to 34. All subjects were required to have a computer administered screening audiogram via the Hughson-Westlake method, with behavioral hearing thresholds within the normal hearing range, 25 dB hearing level (HL) or better from 125 Hz to 8000 Hz. Anthropometric head measurements were collected for each subject. Subjects were assigned a HGU-55/P flight helmet and modified A/P22P-14A (V)3 size based on the anthropometric measurements. Sizing adjustments and all helmet and hood fittings were conducted by a modified A/P22P-14A (V)3 Subject Matter Expert (SME). Anthropometric measurements and assigned sizes for each of the subjects are shown in Table 1.

Table 1. Subjects' anthropometric head measurements and sizing matrix

Subject ID	Head Circumference (mm)	Width (mm)	Length (mm)	SNR (mm)	Neck Circumference (mm)	HGU-55/P Size	JSAM-TA Size
15	540	125	185	82	340	Medium	Small
1382	525	115	180	80	295	Medium	Small
1451	550	125	180	80	290	Medium	Small
1487	550	125	175	83	320	Medium	Small
1534	550	125	190	92	350	Large	Small
1584	570	140	190	81	390	Large	Small
1599	545	125	185	91	345	Large	Large
1601	575	135	200	91	370	Large	Large
1602	525	125	170	86	305	Medium	Small
1603	555	130	185	88	320	Large	Small
1606	535	140	175	81	325	Large	Small
1616	510	125	175	81	275	Medium	Small
1622	525	120	180	70	290	Large	Small
1624	530	135	175	87	290	Medium	Small
1625	565	123	185	89	350	Large	Large
1628	545	140	190	90	370	Large	Large
1629	565	145	190	89	380	Large	Large
1630	510	125	170	87	280	Medium	Small
1631	560	140	190	92	365	Large	Large
1633	530	125	180	88	350	Large	Large

The AFRL facility used for this portion of the study was specifically built for the measurement of the sound attenuation properties of passive hearing protection devices. The chamber (Figure 3), its instrumentation, and measurement procedures were in accordance with ANSI S12.6-1997[1]. The subjects were seated in the center of the room and tasked to respond to a series of tones using a hand-held response wand (Figure 4). ANSI S12.6 requires measuring the occluded and unoccluded hearing threshold of human subjects using a von Békésy tracking procedure. The thresholds were measured two times for the unoccluded ear condition and two times for the occluded ear condition (with hearing protector in place). The real-ear attenuation at threshold for each subject was computed at each octave frequency, 125 to 8000 Hz, by averaging the two trials (the difference between unoccluded and occluded ear hearing thresholds). Due to the ambient noise requirement of ANSI S12.6-1997, the modified A/P22P-14A (V)3 blower was turned off for all attenuation measurements.

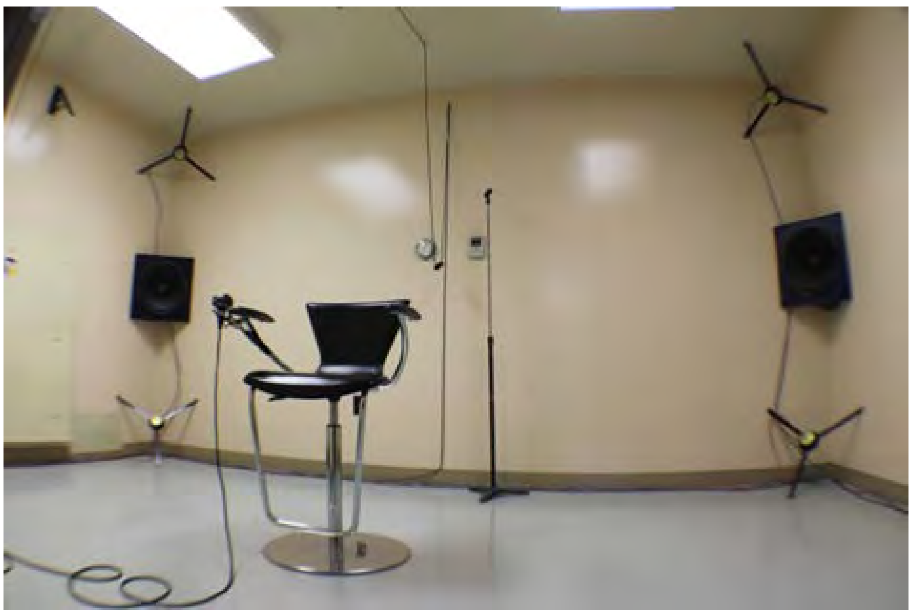

Figure 3. Facility used for measurement of passive continuous noise attenuation

Figure 4. Subject completing the threshold measurement in the HGU-55/P and the modified A/P22P-14A (V)3 configuration

Passive noise attenuation data were analyzed using the methods described in ANSI S12.68-2007 Methods of Estimating Effective A-Weighted Sound Pressure Levels When Hearing Protectors are Worn [4]. This ANSI standard detailed the methods for estimating the effective A-weighted Sound Pressure Level (SPL) when hearing protectors are worn. The octave band method was the "gold standard" method for estimating a users' noise exposure. This method requires both the noise spectra per octave band and the attenuation data per octave band. Mean and standard deviation (SD) noise attenuation data were calculated across subjects at each octave frequency band. A single Noise Reduction Rating (NRR) was also calculated for mean minus 1 and mean minus 2 standard deviations (Table 2). Figure 5 displays a graphical representation of the attenuation results at each measured frequency (mean minus 2 SD).

Table 2. Passive noise attenuation data for HGU-55/P and the modified A/P22P-14A (V)3 configurations with and without ACCES

		Frequency (Hz)							NRR	
Configuration		**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**	Mean -1SD	Mean -2SD
HGU-55/P - Modified A/P22P-14A (V)3	Mean	8	6	14	20	28	36	38	12	8
	SD	5	5	4	3	6	7	7		
	Mean -1SD	4	1	10	17	22	29	31		
	Mean -2 SD	-1	-3	7	14	16	22	24		
HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	Mean	15	16	32	40	48	55	62	22	15
	SD	7	7	6	5	6	6	6		
	Mean -1SD	9	9	26	34	42	49	56		
	Mean -2SD	2	3	20	29	36	43	50		

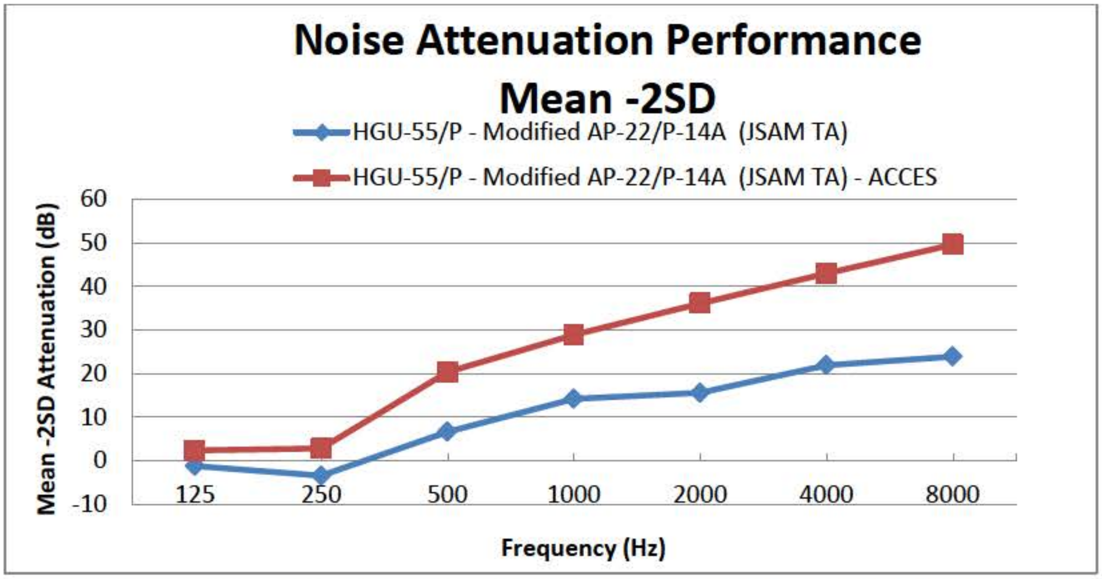

Figure 5. Passive mean -2SD noise attenuation for HGU-55/P and the modified A/P22P-14A (V)3 configurations with and without ACCES

It was not always possible to calculate the effective A-weighted level under the hearing protector using the octave band method due to the lack of detailed noise data for all noise environments. Two other methods were developed and described in ANSI S12.68[4]: Noise Level Reduction Statistics, Graphical (NRS_G) and Noise Level Reduction Statistics for use with A-Weighting (NRS_A). NRS_G was calculated for both configurations and is displayed in Tables 3-4 and Figures 6-7. NRS_A was calculated and is displayed in Figures 8-9.

The NRS_G rating requires knowledge of both the C- and A-weighted noise levels, and uses this additional information about the noise spectrum to more precisely estimate the range of protection provided. For example, if the C-weighted noise was measured at 100 dB and the A-weighted noise was measured at 94 dB then the difference between the two weighting levels would be 6. Therefore, the range of protection provided by the hearing protector could be found in Figure 6 and/or Table 3 where B = 6. NRS_A was appropriate for unpredictable noise environments that could have varied widely as was the case with many military operations. However, for relatively constant (e.g., aircraft or other vehicles) noise environments, then NRS_G should have been used to calculate more accurate attenuation performance values.

Table 3. NRS_G results for HGU-55/P and the modified A/P22P-14A (V)3 configuration

		$B = L_C - L_A$			
Configuration		**-1**	**2**	**6**	**13**
HGU-55/P - Modified A/P22P-14A (V)3	**80%**	21.5	13.0	8.1	4.5
	20%	25.6	18.4	14.6	11.6

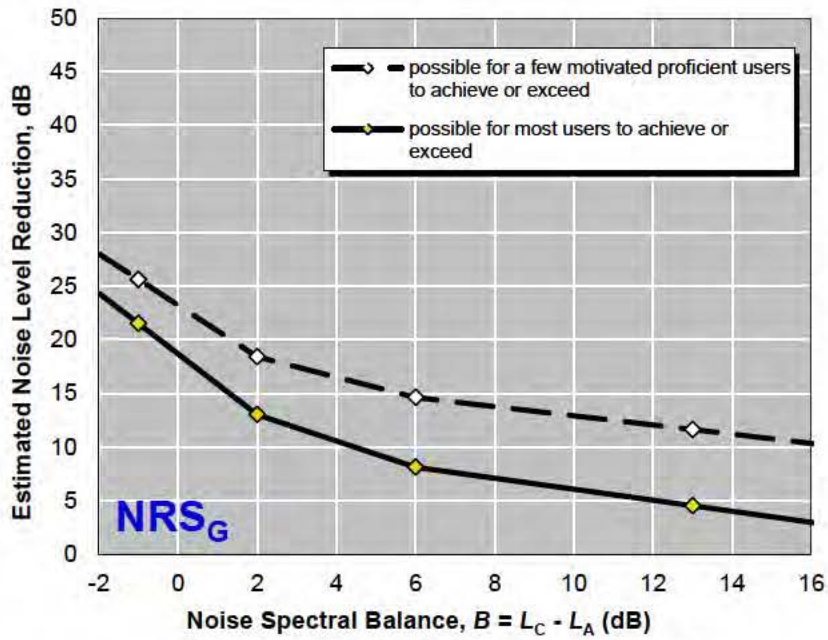

Figure 6. NRS_G results for HGU-55/P and the modified A/P22P-14A (V)3 configuration

Table 4. NRS_G results for HGU-55/P and the modified A/P22P-14A (V)3 with ACCES configuration

Configuration		$B = L_C - L_A$			
		-1	**2**	**6**	**13**
HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	**80%**	34.0	23.1	17.0	11.6
	20%	43.4	33.4	27.6	22.1

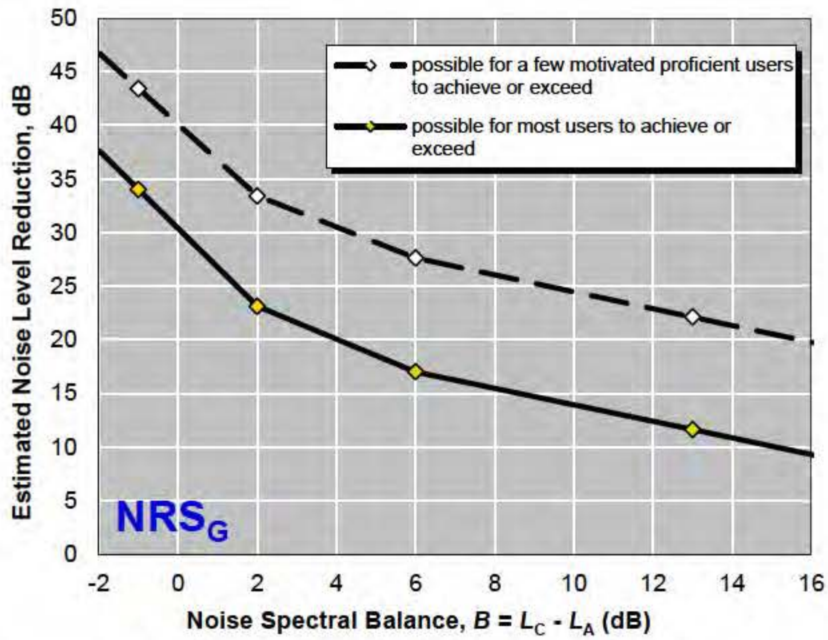

Figure 7. NRS_G results for HGU-55/P and the modified A/P22P-14A (V)3 with ACCES configuration

NRS_A was the simplest method and could have been used by subtracting the attenuation value from the measured A-weighted noise level to estimate the level of sound at the ear under the hearing protector. This method offered several advantages over the well-known NRR. The NRR was developed to be subtracted from the C-weighted noise exposure, with a 7-dB adjustment that must be applied prior to subtracting it from A-weighted exposure values. C-weighted exposure values were often not known, and therefore the rating for subtraction from A-weighted exposures with the NRS_A eliminated these problems with the NRR. Another advantage of the NRS_A was that it calculated two levels of protection to indicate the range of performance that was achieved (Figures 8-9); this range reflected both the variation across the subjects in the test panel providing insight into how hard/easy the device may have been to fit, as well as variation in noise level reduction with the noise spectrum in which the device was used[5]. The majority of users (80%) would have achieved the performance specified by the lower value in the range, with only the most motivated proficient users (20%) able to have achieved the higher value. A narrow range indicated that the hearing protection device provided a more stable and predictable level of protection. When the methods described in ANSI S12.68 (octave band method, NRS_G, and NRS_A) were not used, the use of the NRR (mean-2SD) was acceptable with the use of the appropriate derating.

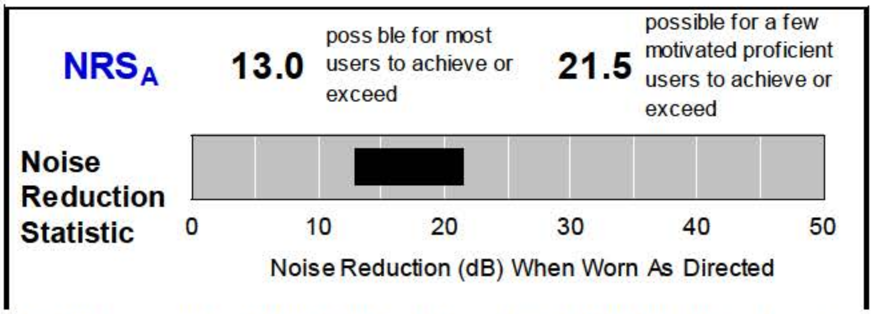

Figure 8. NRS_A results for HGU-55/P and the modified A/P22P-14A (V)3 configuration

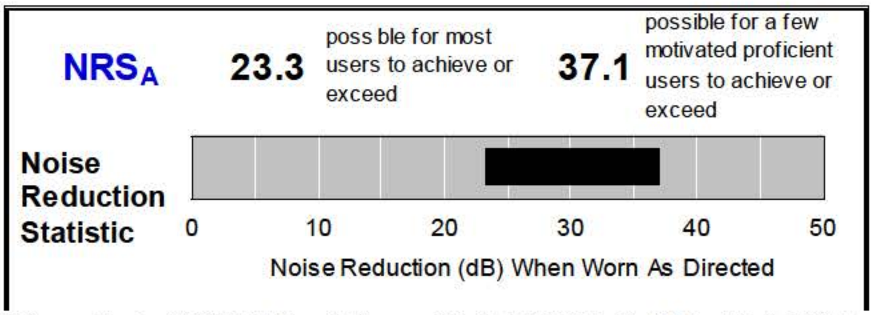

Figure 9. NRS_A results for HGU-55/P and the modified A/P22P-14A (V)3 with ACCES configuration

2.2 Speech Intelligibility

The AFRL VOice Communication Research and Evaluation System (VOCRES) facility was used to measure the speech intelligibility performance of the modified A/P22P-14A (V)3 worn in combination with the HGU-55/P with and without ACCES. VOCRES was designed to evaluate voice communication effectiveness in operationally-realistic acoustic environments. The facility consisted of a programmable, high-power sound system housed in a large reverberant chamber, capable of generating high-level (130 dB sound pressure level) pink noise. Ten operator workstations were positioned in the facility (Figure 10), each equipped with a touch-screen display and communication system capable of replicating end-to-end military communication chains (i.e., intercoms, oxygen systems, headsets, microphones, and helmets). In this way, full communication systems, as well as individual system components, could be evaluated under operational conditions to determine the impact these systems might have on speech intelligibility performance.

Figure 10. AFRL's VOCRES facility used to measure speech intelligibility performance

Six paid volunteer subjects (4 male, 2 female) participated in the speech intelligibility performance measurements. The six subjects were a subset of the twenty subjects who participated in the noise attenuation measurements. All subjects had hearing threshold levels less than or equal to 15 dB hearing level (HL) from 125 to 8000 Hz. The subjects ranged in age from 19 to 30. The subjects had English as their native/1st language and were trained to participate as both a talker and a listener in the speech intelligibility study. All helmet and hood fittings for the speech intelligibility study were conducted by a modified A/P22P-14A (V)3 SME as was done for the noise attenuation study. Anthropometric head measurements and sizing information for each speech intelligibility subject is recorded in Table 5.

Table 5. Subjects' anthropometric head measurements and sizing matrix

Subject ID	Head Circumference (mm)	Width (mm)	Length (mm)	SNR (mm)	Neck Circumference (mm)	HGU-55/P Size	Modified A/P22P-14A (V)3 Size
1584	570	140	190	81	390	Large	Small
1602	525	125	170	86	305	Medium	Small
1622	525	120	180	70	290	Large	Small
1625	565	123	185	89	350	Large	Large
1629	565	145	190	89	380	Large	Large
1631	560	140	190	92	365	Large	Large

Measurements were conducted in accordance with ANSI S3.2[2]. Lengthy donning and doffing times reduced the number of listeners per talker to one. Subjects were divided into pairs (1 talker, 1 listener) and subjects would reverse roles during the measurements for a total of 6 talkers/listeners. The Modified Rhyme Test (MRT) was selected for the

test material. The MRT consisted of 50 six-word lists of monosyllabic English words. The talker read the phrase “You will mark fill please”. The listener then selected a word from a list of six words: fill, kill, bill, will, hill, and till. Each subject completed 3 lists as a talker and 3 lists as a listener per configuration (Table 6). The talker and listener were in the same noise environment for all configurations.

Table 6. Speech intelligibility measurement configuration matrix

Communication System	Configuration	Noise Environment
Modified A/P22P-14A (V)3 Communications Unit (Over-the-Air)	HGU-55/P - Modified A/P22P-14A (V)3	Low Noise 65dB
Modified A/P22P-14A (V)3 Communications Unit (Over-the-Air)	HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	Low Noise 65dB
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3	High Noise 95dB
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3	High Noise 105dB
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	High Noise 105dB
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	High Noise 115dB

Low noise environment measurements were conducted to mimic the ground configuration mode. Subjects were seated at adjacent VOCRES workstations, facing each other, one meter a part (Figure 11). The JSAM-TA Performance Specification[3] required a distance of three meters apart. At this distance, subjects were receiving speech intelligibility scores < 20%. A one meter distance was selected as a more productive distance when compared to the defined 3 meter distance environment. The talker’s voice was transmitted from the microphone mounted inside the modified A/P22P-14A (V)3 mask, over-the-air through the torso mounted communications unit, and received by the listener via his/her communications unit. From the communications unit, the signal would travel to the either the listener’s HGU-55/P earcups or ACCES, depending on the device configuration. Measurements were conducted with the modified A/P22P-14A (V)3 blower off. Supplemental breathing air was provided by connecting the modified A/P22P-14A (V)3 oxygen hose to the facility’s supplied air system. All measurements in the low noise environment were collected at 65 dB overall sound pressure level (OASPL).

Figure 11. Subjects sitting one meter apart during a low noise, over-the-air SI measurement

High noise environment measurements were conducted to mimic the flight configuration mode. Subjects were seated at VOCRES workstations, facing forward, with audio hardwired though the facility's military aircraft intercom system (AIC-25). The talker's voice was transmitted from the microphone mounted inside the modified A/P22P-14A (V)3 mask, though the AIC-25 at the talker's workstation to the listener's workstation via HGU-55/P earcups or ACCES, depending on the device configuration. Measurements were conducted with the modified A/P22P-14A (V)3 blower off. Supplemental breathing air was provided by connecting the modified A/P22P-14A (V)3 oxygen hose to the facility's supplied air system. Measurements in the high noise environment were collected at 95 dB, 105 dB, and 115 dB OASPLs.

Results were combined for all subjects per configuration. The subjects' scores were adjusted for guessing as described in ANSI S3.2. An overall average was then calculated for all subjects per configuration, Table 7.

$$Score = 2(R - \frac{W}{n-1})$$

Where:

$Score$	=	Percent Correct (Adjusted For Guessing)
R	=	Number Correct
W	=	Number Incorrect
n	=	6 (number of choices available to listener)

Table 7. Speech intelligibility (SI) performance

Communication System	Configuration	Noise Environment	Average SI Score (%)
Modified A/P22P-14A (V)3 Communications Unit (Over-the-Air)	HGU-55/P - Modified A/P22P-14A (V)3	Low Noise 65dB	57.9
Modified A/P22P-14A (V)3 Communications Unit (Over-the-Air)	HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	Low Noise 65dB	57.5
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3	High Noise 95dB	92.4
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3	High Noise 105dB	90.3
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	High Noise 105dB	91.9
AIC-25 (Hardwired)	HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	High Noise 115dB	84.9

The HGU-55/P flight helmet and the modified A/P22P-14A (V)3 speech intelligibility performance with and without ACCES in an over-the-air, low noise environment scored an average of 57.5% and 57.9%, respectively. The objective of these measurements was to determine if the JSAM-TA Performance Specification requirements were being met: ≥ 85%. The SI scores for both the modified A/P22P-14A (V)3 configurations with and without ACCES in low noise fell below the contractual requirement and therefore were unacceptable.

The modified A/P22P-14A (V)3 and HGU-55/P with and without ACCES met or exceeded the JSAM-TA speech intelligibility requirement when connected to an aircraft intercommunication system.. The contract required speech intelligibility scores of ≥ 90% at 95 dB, ≥ 85% at 105 dB, and ≥ 80% at 115 dB. The HGU-55/P and modified A/P22P-14A (V)3 configuration met and exceeded this requirement with speech intelligibility scores of 92.4% at 95 dB and 90.3% at 105 dB and was not measured at 115 dB due to poor noise attenuation. The HGU-55/P and modified A/P22P-14A (V)3 with ACCES configuration met or exceeded the contractual requirement with speech intelligibility scores of 91.9% at 105 dB and 84.9% at 115 dB.

3.0 DISCUSSION

The use of CB protection under a flight helmet has the potential to degrade the noise attenuation performance of the helmet and therefore degrade speech intelligibility performance. When compared to AFRL archival noise attenuation data on the HGU-55/P alone, the addition of the modified A/P22P-14A(V)3 hood reduced attenuation by a maximum of 16 dB at 8000 Hz (Table 8). The difference in attenuation between the HGU-55/P and the HGU-55/P and modified A/P22P-14A (V)3 configuration falls outside the Performance Specification requirement of "no more than a 3 dB degradation of the measured one-third octave band compared to the non-CB configuration"[3]. Conversely,

the addition of ACCES to the HGU-55/P and modified A/P22P-14A (V)3 configuration increased attenuation by at least 5 dB per measured one-third octave band (Table 8).

Table 8. Comparison of HGU-55/P vs. HGU-55/P and modified A/P22P-14A (V)3 with and without ACCES

Configuration		Frequency (Hz) 125	250	500	1000	2000	4000	8000
HGU-55/P	Mean	9	8	15	28	37	50	54
HGU-55/P - Modified A/P22P-14A (V)3	Mean	8	6	14	20	28	36	38
Difference (in dB)		(1)	(2)	(1)	(8)	(9)	(14)	(16)
HGU-55/P	Mean	9	8	15	28	37	50	54
HGU-55/P - Modified A/P22P-14A (V)3 - ACCES	Mean	15	16	32	40	48	55	62
Difference (in dB)		6	8	17	12	11	5	8

In legacy systems, passive earplugs (foam) were added to the helmet configuration to reduce the level of noise at the ear; unfortunately, for some users, the added attenuation made it difficult to understand speech. Communication earplugs were developed to improve both speech intelligibility and noise attenuation. These devices ranged from custom (like ACCES) to generic fit eartip systems with varying shapes and materials. The data in Table 8 demonstrates the improved noise attenuation performance of the HGU-55/P helmet with the modified A/P22P-14A (V)3 when used with ACCES resulting in reduced aircrew noise exposure.

The JSAM-TA Performance Specification highlighted two separate communication conditions for the speech intelligibility measurements. The first configuration was intended to simulate a ground configuration mode where individuals wearing HGU-55/P and the modified A/P22P-14A (V)3 could communicate over-the-air to each other via torso mounted communications units. Speech intelligibility scores with and without ACCES were 57.4% and 57.9%, respectively, which fell far below the requirement of ≥ 85%. If the measurements were conducted at three meters apart instead of one meter apart, as stated in Performance Specification, speech intelligibility scores would have been even lower. It is unlikely that any earplug or helmet configuration would improve this situation. A less practical, but more effective approach would be for individuals to hardwire to each other though the communications unit. The second condition was intended to simulate a flight configuration mode where individuals wearing the HGU-55/P and the modified A/P22P-14A (V)3 could communicate hardwired via an intercom/radio system. Both configurations (with and without ACCES) exceeded the speech intelligibility requirements for high noise environments at all measured levels, with scores ranging from 84.9% at 115 dB to 92.4% at 95 dB. Both configurations were measured at 105 dB, with the ACCES configuration achieving a slight advantage over the non-ACCES configuration with 91.9% to 90.3%, respectively. Measurements with the HGU-55/P and the modified A/P22P-14A (V)3 were not conducted at 115 dB due to

noise exposure limitations. The amount of attenuation provided by the HGU-55/P and the modified A/P22P-14A (V)3 configuration was not sufficient to meet the Department of Defense (DoD) noise exposure criteria for a 115 dB noise environment. Although the speech intelligibility performance across configurations was fairly similar, the reduction in noise exposure while donning the modified A/P22P-14A (V)3 with the HGU-55/P requires additional noise attenuation. ACCES provided the additional attenuation and with the modified A/P22P-14A (V)3 and HGU-55/P met or exceeded the speech intelligibility requirements.

4.0 SUMMARY/CONCLUSIONS

Noise attenuation and speech intelligibility measurements were conducted at AFRL in accordance with ANSI 12.6 and ANSI S3.2, respectively, in May 2015. Measurements were collected on the HGU-55/P and the modified A/P22P-14A (V)3 CB hood with and without ACCES to determine if JSAM-TA Performance Specification requirements were met. When worn in combination with the HGU-55/P and the modified A/P22P-14A (V)3, the ACCES increased noise attenuation across all frequencies, ranging from 125 Hz to 8000Hz, when compared to the helmet/hood configuration alone. Both configurations failed to meet the speech intelligibility requirement for low noise environments of ≥ 85%, with scores for both configurations at 57%. Speech intelligibility requirements for high noise environments were exceeded at all measured levels, with scores ranging from 85% to 92%.

5.0 REFERENCES

1. ANSI S12.6-1997 Methods for Measuring the Real-Ear Attenuation of Hearing Protectors Systems.
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